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Highly Enhanced Risk Management Emergency Satellite

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HERMES

Highly
Enhanced
Risk
Management
Emergency
Satellite

Highly Enhanced Risk Management Emergency Satellite.

Technical University München,

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1. HERMES MISSION OBJECTIVES

The HERMES Satellite is designed to provide information to reduce the risk of floods or to even avoid them (flood management) and monitor the Earth surface. If there is a need in future, satellite's payload and the bus can be used on other planets. The mission objectives comprise:

– Emergency procedures: crisis management and damage assessment (also use: real-time data about surface water, precise Digital Terrain Model (DTM)
  - o identify critical/decisive moments during a crisis
  - o identify plans/responses to overcome the crisis or minimize the damages

– Forecasting: risk assessment and prediction (also use: long-term data from rain, rivers, lakes, soil moisture, precise DTM)
  - o what will happen in case of a flood (damage classification)
  - o how probable is a certain risk scenario (probability classification)

– Prevention: avoid floods (also use: of data of land use, surface sealing, precise DTM)
  - o establish conditions that will generally avoid floods
  - o establish actions if several flood risk factors add up (which might interact)

2. OPERATIONAL REQUIREMENTS

To achieve the mission objectives, the operational requirements are specified as follows:

Orbit (see also Ch. 4 Orbit Selection for details)
- – Cover whole earth surface in three days
- – Low to provide good resolution but high enough for operational lifetime of five years
- – Maximum solar power use

SAR sensor (see also Ch. 6 Scientific Payload)
- – SAR sensor shall sense surface water
- – High resolution (10 m to 100 m)
- – SAR sensor must produce data that can be used for simple reflectivity, polarization and interferometry, as
  - o single radar pictures (2D reflectivity => surface-water Yes/No)
  - o polarization for quality & details
  - o interferometry
- - Same time, different place => precise height
- - Same place, different time => very precise height change

Spacecraft bus (see also Ch. 5. Spacecraft bus)
- – Orbit stability and attitude control in such a way that
  - o HERMES can be lifted from initial to final orbit,
  - o HERMES can be kept at target altitude,
  - o Attitude: HERMES SAR beam can be pointed precise enough,
  - o Orbit: kept sufficiently precise,
  - o Propulsion scheduled to last full life-time
- – Command and data handling subsystem
  - o runs stable and free of error,
  - o without data lost.
- – Communication subsystem
  - o provides smoothly working communication,
  - o without time-lag for data transmission.
- – Power subsystem
  - o ensures power provision during operational lifetime.
- – Thermal control subsystem
  - o keeps the thermal equilibrium of the satellite.
- – Structures and mechanics
  - o carry and protect the other subsystems.

Ground segment (see also Ch. 6. mission architecture)
- – ensures good global coverage for a quick and persistent access to data,
- – provides a data rate for no lost of data,
- – keeps redundancy.

3. SYSTEM ARCHITECTURE AND PROJECT PHASES

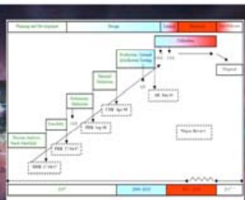


Figure 3.1 Project phases

4. ORBIT SELECTION, COVERAGE and PROJECT PHASES

The SAR satellite orbit altitudes are usually in the range of 500–800 km. The orbital parameters of several Earth observation satellites (e.g. Envisat, ERS-2, Radarsat and JERS-1) have been studied and compared. For HERMES mission, to make the satellite energyefficient, a Sun-synchronous dusk-to-dawn orbit has been selected. Considering initial sensor parameters (e.g. swath width and look angle, specified by scientific objectives) a simulation was conducted using Satellite Tool Kit (STK) software. As a result, trying several options, we found out that at altitude 770 km and inclination 98.2 degrees the SAR antenna is able to cover whole Earth surface in 3 days (72 hours). The coverage is shown in figure below. Three different colors show satellite orbital paths within 3 days.

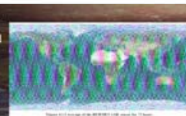


Table 4.1 Orbital parameters

Orbital parameter	Value
Altitude	770 km
Inclination	98.2 degrees, sun synchronous
Orbital period	100.26 min
Orbital velocity	7.47 km/s
Number of Revolutions per day	14.36
Sunlight time	nearly 24 h
Eccentricity	0.00012[illegible]
Repeat cycle	35 days

5. SCIENTIFIC PAYLOAD

THE HERMES L-BAND SYNTHETIC APERTURE RADAR (HLSAR)

The HERMES Synthetic Aperture Radar (HLSAR) is an active microwave sensor to be used day and night, independently from weather. As it uses the L-band, it is very well able to penetrate through the canopy. The sensor has an electronically steerable beam with variable swath width, which allows obtaining a wider swath than conventional SARs.

Figure 6.1 Primary interactions of microwaves with canopies

Observation Modes

Related to different swath widths and polarization methods, HLSAR has 3 observation modes, each of which provides specific functionality:

Table 6.1 HLSAR observation modes (partially adapted from ALOS PALSAR sensor)

	High resolution	WideSAR	Polarimetric
Specific functionality	High spatial resolution	Wide area coverage	High discrimination of reflectivity
Polarization	HH or VV	HH+HV or VV+VH	HH+HV+VV+VH
Resolution	15 m (2 look) – 30 m (4 look)	30 m – 120 m (2 look)	30 m (multi look)
Swath Width	50 km	100 km – 500 km	50 km
Incidence Angle		8 – 60 °	
Data Rate		240 Mbps	
Frequency		1270 MHz (L-Band)	

Technical Specifications

The HLSAR antenna dimensions are 10 m x 2.9 m. The off-nadir angle of HLSAR is variable between 7.2° and 51.4° (at mid-swath), corresponding to an 8 - 60.0° incidence angle range. The SAR signal can be created of single (HH or VV), dual (HH+HV or VV+VH) or quad (HH+HV+VV+VH) polarization.

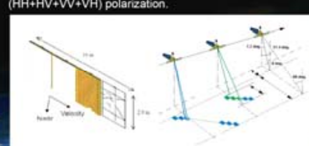
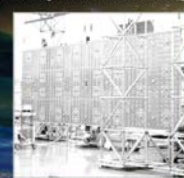


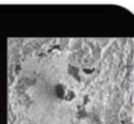
Figure 6.2 HLSAR Antenna and Imaging Swath range. Diagram Adapted from ALOS L-Band Sensor system [Ohno, 2006]



6. POST-PROCESSING PRODUCTS

Reflectance Imaging

The sensor transmits a microwave signal to the earth surface. It then detects the energy of the received signal after it is scattered on the surface. As the signal is not transmitted in nadir direction, the more it is scattered the more energy the sensor receives (smooth surfaces like water or metal do not scatter but reflect). So water appears to be black and it can be very well distinguished from land.



Polarimetry

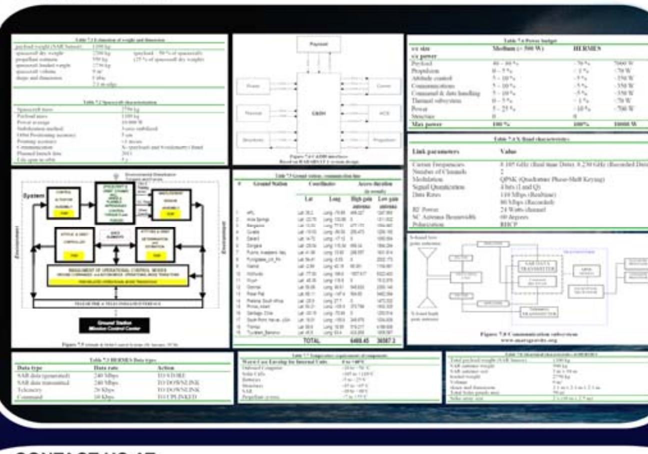
A radar signal reflected from an object generally changes its polarization, which is very sensible to the surface of the reflecting material. By comparing the horizontal (H) and vertical (V) polarization of the reflected and the transmitted wave, the surface of the reflector can be analyzed in terms of polarized wave intensity and phase.

As HLSAR can acquire H and V for both sending and receiving signals (full polarimetric SAR), it has a high capability to detect water content in vegetation, monitoring of snow cover, condition of ice, flood monitoring and soil moisture.

Interferometry

HLSAR data provides the phase information of the received microwaves, reflecting the distance between HLSAR and a target. Comparing the phases of two HLSAR signals acquired from different near points in orbit with known distance (Master, Slave), targeting the same area on ground, the elevation of the area can be computed. With this analysis method very precise elevation data can be derived (DTM).

7. SATELLITE BUS



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